

REVIEW ARTICLE

Sustainable small-scale animal agriculture and food security in Africa

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ABSTRACT

For Africa, smallholder livestock farming is crucial for rural livelihood and food security. Understanding the connections between food security, gender inequality, and climate change can help us find solutions to Africa's persistent food crisis. Women's participation in small-scale animal agriculture helps ensure the food security of households; however, climate change has a detrimental effect on animal productivity, so prioritizing climate-smart animal husbandry techniques is critical. The shift in animal agriculture toward sustainability must be fueled by gender-sensitive strategies. Production and food security will improve through a transdisciplinary strategy that recognizes the connections among small-scale animal agriculture, climate change, and gender issues. Policies that are adapted to local conditions and encourage equitable growth in small-scale animal agriculture will be necessary to address the challenges this sector faces and improve food security. The majority of developing nations have institutional and technical obstacles that could prohibit the small-scale farming sector from participating in new food security efforts aimed at enhancing rural livelihoods. Therefore, it is highly doubtful that any strategy created to improve food security while downplaying the importance of smallholder agriculture will be long-term viable. The discussion makes clear the importance of small-scale animal agriculture and offers potential solutions that could be adopted to transform the small-scale animal agriculture sector to increase its value and enhance food security across the continent.

Keywords: small-scale animal agriculture; food security; climate change; gender inequality; local animal genetic resources; crop-livestock integration

1. Introduction

Animal agriculture is crucial to the food security of developing countries. The consumption of animal-related products is also expanding significantly. According to Sejian et al.^[1], in the past 20 years, wheat output in developed nations increased by 78%, fish production by 113%, meat production by 127%, and egg production by 331%. The fastest increases in meat production have been in pigs and poultry. Nevertheless, many people in developing countries cannot afford animal products, which results in them eating 17.7 kg less meat yearly than people in developed countries (81.6 kg). Only 22% of the protein consumed in developing countries comes from animal sources, compared to around 60% in wealthy countries.

In the context of African agriculture, inclusive growth refers to the expansion of the agricultural sector in a way that benefits rural populations broadly while enhancing local and global food security and economic productivity^[2]. This is against the backdrop of Africa's population growing to 1.3 billion by 2050, the largest

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in the world^[3], and another 4.5 billion by 2100, with serious implications for food demand and security. As part of the ongoing debate and solution-seeking under the SDGs' top development priority of global food security, small-scale animal agriculture provides a path out of poverty and food insecurity for many of the world's poor, particularly in Africa. Through production-consumption linkages, SCAA has the potential to improve food security by increasing production, cutting back the actual cost incurred on food by increasing supply, and providing income to resource-constrained rural farmers, their households, and communities, as well as other sectors in the rural economy. Local animal genetic resources have continued to be a major component of food production in arid and semi-arid tropics, particularly in marginal and sub-marginal lands, and may be considered the best biodiversity for utilizing the sparse vegetation present in dryland areas through rangeland management and reseeded pastures^[4]. Thus, the major issues that Africa must address include improving food security by combating poverty and achieving agricultural growth that will contribute to overall economic development and, later, the SDG's^[5].

The demand for agricultural food in Africa is anticipated to continue to be primarily driven by rapid population growth. This situation calls for the development of unique African-tailored strategies to aid in the transformation of resource-poor animal agriculture in Africa in order to address the critical issue of food insecurity^[6]. In the agricultural sector, women play a significant role in food production, agricultural transformation, rural development, and household food security. Gender equality can contribute significantly to a country's economic growth^[7], and it is the most important determinant of food security^[8]. The World Development Report^[7] emphasizes the importance of gender equality in increasing agricultural productivity and proposes a gendered approach in which men and women complement each other in making the best use of resources to increase food production, thereby offsetting food insecurity with increased animal production. Gender inequality should be addressed in the planning and implementation of food production programs to improve food security so that women are not excluded from food production.

In order to achieve sustainable animal development in the face of the intensifying impacts of climate change, small-scale animal agriculture needs to simultaneously achieve three goals: i) increase agricultural productivity and household incomes; ii) adapt to the impacts of climate change; and iii) contribute to climate change mitigation, where possible. Climate change can be mitigated by encouraging mixed farming, because on average, the more diverse an agricultural system is, the better it adapts to climate change. A detailed diagnosis of the dynamics of climate-smart animal production techniques will guide any future livelihood and food security intervention programs that take important socioeconomic issues into account in order to improve the standard of living of Africa's rural poor. Similarly, the importance of incorporating gender perspectives into climate change policies or adaptive measures in the agricultural sector in order to improve food security has been widely recognized^[9].

SCAA structural remediation that provides information and resources to resource-poor farmers is the most effective way to improve animal production-related output and food security. According to Sowińska-Świerkosz and García^[10], nature-based solutions are interventions that take advantage of nature's ability to provide ecosystem services in order to improve resilience in agriculture and food production while reducing climate change and enhancing the environment. Due to the smallholders' severe resource shortage and dependence on the limited local resources, this has a very high chance of success as a component of small-scale animal agriculture. The continent requires a multidisciplinary scientific approach to transform small-scale animal agriculture and improve food security because of persistently declining animal output, declining grazing and poor-quality forage, diminishing returns to animal labor, and a situation where population growth has outpaced increases in animal productivity. The discussion makes clear the importance of small-scale

animal agriculture and offers potential solutions that could be adopted to transform the small-scale animal agriculture sector to increase its value and enhance food security across the continent.

2. SCAA is characterized by a variety of terms

A family serves as the primary decision-maker and implementer within a web of connections at the community level in the vast majority of small-scale farming endeavors. Dixon et al.^[11] categorized African smallholder farmers in three classes based on different variables: (i) the agro-ecological zones in which they operate; (ii) the type and composition of their farm portfolio and land holding; or (iii) on the basis of annual revenue they generate from farming activities. In densely populated areas, smallholder farmers typically cultivate less than one hectare of land, but in sparsely populated semi-arid areas, this can rise to 10 ha or more, occasionally in conjunction with livestock of up to ten animals. Due to the fact that their products are not sold in official, organized markets, it is difficult to determine the sources of farm income for smallholder farmers.

Different terminology has been used to define Africa's resource-poor rural farmers; terms like "smallholder," "subsistence," and "peasant" farmers have been interchangeably employed in various contexts. Despite their widespread use, their definitions of "subsistence agriculture," "smallholder agriculture," and "peasant agriculture" are remarkably inconsistent. "Smallholder agriculture" is a term that refers to rural farmers, mostly in developing nations, who cultivate with primarily family labor and rely on the farm for their primary source of income^[12]. In the present study: *A "small scale farmer" is a rural farmer who relies heavily on mixed crops and indigenous animal genetic resources (livestock and avian species) to sustain their livelihood on designated family-inherited land less than 2 ha in their communities of origin.* The high level of diversity in the smallholder farming sector is a result of Africa's diverse agro-ecology, socioculture, economy, and demographics.

The definition of "peasants" proposed by Ellis^[13], for example, is similar but emphasizes membership in larger economic systems and imperfect markets. Other definitions currently in use are focused on some of the traits that smallholder farmers share, including the ability to acquire land and its size^[14,15], labor^[16], resource availability, or capital^[17]. Therefore, depending on the context and geographic location, the definitions and characteristics of small-scale agriculture in Africa might differ^[18–20]. Small-scale agriculture is not conventionally or universally defined, and the terms family farmer, small-scale, resource-poor, subsistence, and low-income are frequently used interchangeably^[21,22].

Subsistence farming has been defined by Barnett^[23] as "farming and associated activities which together form a livelihood strategy where the main output is consumed directly, where there are few, if any, purchased inputs, and where only a minor proportion of output is marketed." However, the term is also sometimes used to denote the activity of self-provisioning with agricultural produce or a relative move toward such activity, as in developments in Eastern Europe following the end of the planned economies^[24]. It is also frequently used in a nontechnical sense to describe the rural poor in developing countries. Such a usage obscures the fact that market relations have pervaded agriculture in almost every country and that many of these farmers' most pressing issues come from the terms of their market participation^[12].

The term "smallholder and subsistence farmers" is used to describe farmers who fall between subsistence farming and concentrating on crop production for the market. Smallholders in transitional or developed countries may have farms (and earnings) several times larger than those in poor countries, and definitions by scale are relative to national circumstances. These systems have been described as "complex, diversified, and prone to risk^[25]." Farms are typically small, are held under traditional or informal tenure, and are located in risky or marginal areas. Pastoralists, who almost entirely rely on the sale of livestock and livestock products to buy staple foods and other necessities, and people who rely on artisanal fisheries and aquaculture

enterprises^[26], are examples of people who rely on the sale of livestock and livestock products to buy staple foods and other necessities. All face similar issues related to isolation and low levels of technology, as well as uncertain exposure to global markets, in varied degrees.

3. The significance of SCAA in ensuring food security

Smallholder farms constitute approximately 80% of all farms in SSA and employ about 175 million people directly^[14,27]. The World Rural Strategy describes smallholder farmers as those with a marginal asset base, farming on only two hectares of arable land^[14], which can be even smaller by 2050. Of significance, SSA typifies the most rural region worldwide, where over 60% of the population has inhabited rural areas since 2014^[28,29]. This is often on the background that smallholder farmers and their entities remain the powerhouse of agriculture and food production, producing the bulk of agriculture and food products and acting as a social safety net in the absence of other livelihood security^[30]. There's a consensus that a smallholder-led agriculture and food production strategy could also be a viable option for agricultural development in Africa^[31,32], hence the attainment of food security.

Small-scale animal husbandry contributes to food and nutrition security for resource-poor rural farmers by providing a diverse range of products from its endowment of livestock and avian species. Smallholders rely on livestock and rural poultry species for milk, meat, eggs, wool, and dung, making an essential commitment to household food and economic security, as well as playing significant economic, social, and cultural responsibilities. Foods derived from animals provide a complete, high-quality, and easily digestible source of protein, as well as vitamins and minerals^[33].

Despite the fact that foods derived from animals constitute a key part of many diets, their consumption differs greatly. Annual meat intake, for example, varies greatly between countries^[34]. Foods derived from animals' commitment to household food security and nutrition are both well-coordinated to provide nutrient-rich and affordable products for human consumption and indirectly improved through improving crop, vegetable, and other livestock production through the supply of manure and pest control^[35]. Because they have smaller stomachs, young children, for example, require diets that provide nutrients more efficiently. Furthermore, nutrition has an impact on both morphological and biochemical processes in the brain; as a result, nutrients present in animal-derived meals are essential for cognitive development and maternal nutrition^[36]. Regular ASF consumption has been shown to improve children's nutritional status, linear development, and educational outcomes, resulting in improved adult income and productivity^[37]. Animal-derived meals aid memory, bone health, muscle mass, and a variety of other functions in people as they age^[38].

Foods derived from animals additionally make a contribution to food accessibility because the farm earnings enable households to purchase from marketplaces different food supplies that they no longer develop on their farms, which include fruit and vegetables. Poor individuals frequently consume little or no foods derived from animals for a variety of reasons, including a lack of availability, accessibility, and dietary habits influenced by conventions, religious taboos, or a lack of information about the nutritional value of foods derived from animals. Eggs and milk are high in nutrients; in particular, eggs contain all of the elements necessary for a chick's growth, and it is thought that they have a virtually ideal mix of nutrients to suit human nutritional needs^[39]. Animal-derived foods are the only natural sources of vitamins and are essential for human nutrition throughout the life cycle, especially at specific stages. Meat and edible offal, meanwhile, include high-quality proteins as well as essential fatty acids, which might be monounsaturated, saturated, or polyunsaturated.

The establishment of a consensus on the institutionalization of small-scale animal agriculture systems to change and transition into food systems thinking in Africa and promote it as a key component of the continental

agriculture development agenda is significant and supersedes the definitions aspect in this context, besides its promotion of local food crops and animal species that impact resilience within the African food systems. Farms with less than two ha create roughly 30% of Africa's total agricultural output, while farms with 4–20 ha produce another 50%^[40]. Small-scale farming is worth paying attention to, especially in Africa, where smallholder farmers account for over 70% of the population and operate on parcels of land totaling less than two hectares on average^[41]. As a result, Africa's best alternative for tackling food insecurity is small-scale agriculture.

According to Lowder et al.^[42], Africa has 51 million farms, with 80% (41 million) of them being under two hectares, and their numbers are still increasing in most countries^[43]. More than two billion people rely on 500 million smallholder farms around the world, which supply around 80% of the food in Sub-Saharan Africa and Asia^[41]. In fact, small-scale farmers, who make up about 70% of the population, are now widely recognized as the largest sector group participating in most of the food and agricultural value chains on the continent.

4. SCAA's livestock and avian animal genetic resources endowment and food security

Food security in Sub-Saharan Africa is linked directly and indirectly to the endowment of livestock and avian animal genetic resources. If this link is understood, it can be used to address Africa's ongoing food insecurity. Africa has a diverse range of animal genetic resources that have been underutilized in the past but have the potential to significantly contribute to food security and wealth creation on the continent^[44,45]. More than 800 million impoverished livestock keepers in developing nations raise nearly one billion heads of livestock in marginal, rural, and peri-urban settings^[46]. Africa's livestock account for one-third of the world's livestock^[47] and around 40% of the continent's agricultural GDP, ranging from 10% to 80% in different nations^[48].

The most frequent animals in Africa include cattle, sheep, goats, donkeys, camels, and poultry^[49]. Because the demand for animal-source food (ASF) is predicted to expand as a result of population expansion, rising incomes, and urbanization, livestock will play a larger role in Sub-Saharan Africa (SSA) in the future. Common livestock species are chickens (*Gallus domesticus*), ducks (*Anas platyrhynchos*), turkeys (*Meleagris gallapavo*), quail (*Coturnix japonica*), guinea fowl (*Numida meleagris*), ostriches (*Struthio camelus*), cattle (*Bos taurus*), sheep (*Ovis aries*), and goats (*Capra aegagrus hircus*) (*Sus scrofa*). Africa's total livestock population is estimated to reach two billion poultry birds in 2018 (1.9 billion chickens, 26 million guinea fowl, 27 million turkeys, and 22 million pigeons)^[50]. Cattle, sheep, goats, pigs, chickens, and a dozen or so lesser-known but locally important animals (such as guinea fowl, yaks, and camels) make complicated and diversified contributions to the diets of the world's seven billion people^[49]. They include both direct and indirect effects on the overall food supply and food and nutrition security^[51]. However, production varies widely because of variances in breeds, management approaches, and, especially, adverse weather circumstances like excessive heat, limited water, and scarce foliage.

According to reports, around 70% of the rural poor in Sub-Saharan Africa, or 150 million people, are at least partially reliant on cattle to support their livelihoods, with the majority of them being pastoralists^[52,53]. In Africa, the cattle industry contributes between 30% and 80% of a country's agricultural GDP. Sub-Saharan Africa is home to a huge number of livestock, particularly ruminants, accounting for 20–25% of the world's ruminants. As a result, Sub-Saharan Africa has more long-term grazing areas than any other continent^[54], with cattle production accounting for over 35% of agricultural GDP^[55] and pig farming is also gaining popularity in Africa south of the Sahara.

Africa raises 1.5 billion chickens, with 80% of them belonging to local chicken groups^[56]. Guèye^[57], Aboe et al.^[58], and Faustin et al.^[59] believe that indigenous chickens contribute significantly to the food security and economic sustainability of rural households. Chickens are the most populous animal species ahead of chickens and account for over 2.1 billion heads of livestock in Africa by 2020, and several studies^[60,61] claim that raising hens helps to alleviate poverty and improve household food security. Rural poultry, dominated by village fowl, accounts for more than 80% of all poultry holdings in many developing countries^[62]. In many developing nations, village hens play a key role in poverty reduction and household food security^[63].

One of the reasons why chicken farming would be viewed as a rapid way to try to reduce rural poverty, according to Erasmus^[64] and the South African Poultry Association^[65], is because it is a type of farming that most rural people are familiar with. The goal is to induce rural farmers to raise chickens on a semi-intensive scale in order to supplement their nutrition and food security while also enhancing their incomes. Africa's rural development partners and stakeholders must collaborate to boost and improve rural poultry production, particularly the village chicken, in order to reduce poverty, provide food security, and promote rural livelihoods.

The majority of rural households on the continent raise “village chickens,” which mostly consist of indigenous or infrequently crossbred species^[63]. Despite their small flock sizes, rural poultry flocks account for 60–90% of the chicken population in Africa and Asia^[66]. Rural poultry accounts for 20–32% of total animal protein intake and 70–90% of poultry products^[67]. Chicken farming on a small scale is typically integrated into mixed-production systems with crops and other livestock, and it allows vulnerable households to share their risks^[68]. Birds are often foraged in free-range settings, although additional food can be provided, and housing should be modest and fashioned from locally available materials if possible^[69]. Indigenous breeds are commonly utilized for rural chicken production because they are resilient, resistant to common diseases, and require less attention than exotic varieties.

Diversification of indigenous livestock and poultry portfolios at the family farm level is a potential strategy for enhancing climate resilience and, as a result, the well-being outcomes of smallholder animal agriculture to strengthen food security. In an effort to address the problem of food insecurity, resource-poor smallholder livestock farmers have implemented specialized technology and livestock and poultry husbandry methods as household coping mechanisms to deal with the effects of increasing local resilience in livestock production systems. These adaptation strategies aim to mitigate the detrimental effects of climate change on indigenous livestock and poultry production, hence ensuring food and nutrition security.

Goats and sheep were the next most common livestock species on the continent, with 490 million and 420 million heads, respectively. There are around one billion goats in the globe, with developing nations home to 96% of the goat population^[70]. Africa is home to around 35% of the world's goat population^[71]. Goats account for 30% of the domestic ruminants currently found on the African continent^[72]. In Africa, goats play a critical role in improving livelihoods and food security. In rural locations across Africa, the majority of indigenous and regionally adapted goats are kept in small-scale production systems. Goat meat production in Africa increased from 1.1 million tons in 2008 to 1.3 million tons in 2017^[50], with the bulk of goat meat being produced and consumed locally (within households)^[73,74].

In underdeveloped countries, goat farming is an important agricultural sector. Goats can be managed with ease compared to cattle because they are browsers and also small in size^[75,76]. Goats are a primary or additional income source for many families in resource-poor areas. Although often considered inferior to other livestock, the resilience of goats and their ability to thrive in a range of environments mean that they are of particular value. Furthermore, goats emit less methane than other livestock species^[77].

Locally adapted goat breeds are raised for milk and meat in low-income nations, such as those in Asia, Africa, and Latin America. In dry and drought-prone regions, goat milk is frequently the only source of protein for young infants^[78]. According to studies by Singh et al.^[79], Neupane et al.^[80], Ngambi et al.^[81], Islam et al.^[82], and Byaruhanga et al.^[83], the majority of goat owners in countries where the majority of goats are found are from the lower socioeconomic strata, and in rural areas, goats are primarily managed by women and children^[72,84].

In spite of this, goats are a significant source of food and money in Africa, making up 30% of the continent's ruminant livestock and providing 17% and 12% of the continent's milk and meat, respectively^[72]. There are many different types of production systems, including extensive pastoral and transhumance systems, smallholder intensive systems, smallholder mixed crop-livestock systems, and large-scale ranching systems^[84,85].

5. SCAA, food security and sustainable development goals

Small-scale animal agriculture is crucial to achieving several of the Sustainable Development Goals (SDGs), and it is directly related to the majority of SDGs^[86]. More recently, the UN Committee on World Food Security proposed draft recommendations on sustainable agricultural development for food security and nutrition, including the role of livestock^[87]. The market need for livestock products in emerging countries, which is being driven by population growth, growing incomes, and urbanization^[88], has a considerable potential to be met by a large number of poor smallholder livestock farmers, processors, and marketers, many of whom are women. Meat, milk, and eggs from livestock contain essential nutrients that contribute to food and nutrition security^[89]. Small-scale animal agriculture provides important avenues for advancing gender equity. A sizable share of the rural livestock keepers with limited resources are women. Rural poultry and small stock are sometimes the only livestock assets that women are allowed to own. Women are frequently responsible for changing small-scale animal husbandry into more sustainable systems, much as women's livelihoods in poor nations are frequently empowered through rural poultry and small stock^[90].

The average level of agricultural productivity in Africa is quite low^[91], which does not keep pace with population expansion and leads to an increase in food demand. Over the next decade, the continent's population is expected to grow to be the world's largest, making food a top priority. The Sustainable Development Goals (SDGs) of the United Nations (recognizing the connections between supporting sustainable agriculture, empowering small farmers, promoting gender equality, ending rural poverty, ensuring healthy lifestyles, and combating climate change^[92]) are to end hunger, improve food security and nutrition, and promote sustainable agriculture. This resonates well with livestock being central to reaching the Sustainable Development Goals by transforming rural areas. Livestock is an avenue to deal with SDG 1 (no poverty) and SDG 2 (zero hunger). Capacity building for small-scale farmers will improve their livelihoods, resulting in rural development, poverty reduction, and food security.

The expansion of smallholder animal agriculture can have a significant impact on the rest of the rural economy, particularly when farmers spend their additional money on locally produced goods and services. By improving the effectiveness of small-scale animal agriculture production in Africa, particularly the productivity per animal, it is conceivable to enhance livestock productivity, and this should be done taking into account the livestock production consequences on the environment, especially the concerns about reducing greenhouse gas emissions in those countries. The debate over how smallholder livestock production systems can help achieve the Sustainable Development Goals has thus far mainly centered on how the sector can increase production in order to meet the soaring demand for animal products and feed a growing world population while also minimizing its environmental impact. There are numerous chances to adapt to climate

change and reduce greenhouse gas emissions in a sustainable cattle sector. For instance, the numerous small- and medium-sized farmers around the world can significantly cut these emissions by improving the efficiency of their animal production.

Also in this circumstance, if properly adapted, micro livestock (local small stock and rural poultry)^[93] as a subsector of small-scale animal agriculture appear to have a bright future in alleviating food insecurity, particularly in rural Africa, where farm sizes have continued to shrink due to increased population density. Given the significance of food security to Africa's development goal, which includes achieving the Sustainable Development Goals, it's critical to raise awareness among policymakers and funding agencies about the importance and multiple roles of small-scale animal agriculture, as well as ways to improve small-scale animal production for food security. Food security is a broad concept that includes issues related to the nature, quality, food access, and security of the food supply^[94]. It has been claimed that a larger range of benefits may be attained by realigning small-scale animal agriculture to better meet the UN's 2030 Sustainable Development Agenda. These include enhanced food and nutritional security for the local population, promoting gender equality, and improved environmental management. This discussion attempts to highlight literature that demonstrates and describes linkages between small-scale animal agriculture and food security in Africa with limited resources (resource-poor settings).

Developing policies that are adapted to local conditions and intended to encourage equitable growth, which includes this sector, will be necessary for countries to address the issues that small-scale animal agriculture faces. Despite being the cornerstone of cattle production, this industry has historically been ignored for unknown reasons. For the UN's 2030 Sustainable Development Agenda to be realized, it will be especially important to take steps to empower smaller-scale livestock and rural poultry producers so that they can play a major role in the sector's sustained expansion and reap its benefits. In order to sustainably enhance agricultural productivity, especially in the small-scale farming sector, and to strengthen the animal products-related food supply chain for better nutrition, a lot more work and innovation will be required as the African population continues to expand. It is crucial to comprehend this enormous diversity of small-scale animal agriculture practices and the various actions it necessitates in order to best utilize animals and enhance productivity.

6. SCAA's net direct and indirect impact on food security

Due to a growing continental population and, of course, the trends in urbanization, which have been extremely high on the continent, the demand for animal-related products in Africa is expected to double in the coming decades. This implies that assessing animal agriculture's contribution to continental sustainable food production and security requires a sufficiently developed combined eco-agricultural and agricultural-social perspective, culminating in an eco-agro-social perspective. Without it, the capacity to improve the needs of individuals in terms of food production and security per unit ecological resource available cannot be accurately estimated, given actual ecological source and sink constraints. While maintaining smallholder livestock systems while preserving the environment and biodiversity is viable, there may be trade-offs to take into account, such as less effective livestock value chains and higher consumer prices for livestock goods.

Livestock's net direct and indirect impact on food and nutrition security in the smallholder farming sector has been emphasized^[95] and notably in other literature sources. According to estimates based on data from 2001 to 2003, grazing systems produce 9% of global meat and 12% of global milk; mixed crop-livestock systems provide 46% of meat, 88% of milk, and 50% of cereals; and intensive systems provide 45% of meat and 45% of milk^[96]. Animal products are not only a source of high-quality food, but they are also a source of cash for many small farmers in developing nations, allowing them to buy food and agricultural inputs, which include fertilizer, seed, and pesticides.

Animal agriculture is a component of mixed livestock and cropping systems that characterize smallholder farming systems across Africa; as a result, small-scale animal production reduces the risks associated with cropping systems, particularly during bad seasons. The crop-livestock integration systems have taken advantage of nutrient recycling as an essential component of a sustainable smallholder farming system to enhance food production and security^[97]. The integration of livestock and crops apart from allowing for efficient nutrient recycling, the crop residues, such as cereal straws, as well as maize and sorghum stovers and groundnut haulms have been used as animal feed to improve livestock productivity and household food security. In addition to the direct contribution of plant nutrients, manure provides important organic matter to the soil, maintaining its structure, water retention, and drainage capacity. All this is geared towards improving food production and securing food security.

Small-scale animal agriculture can make a significant contribution to the efficient use of existing natural resources through the provision of economic stability for small-scale farmers by serving as a cash buffer (small stock and mini-livestock) and a capital reserve (large ruminants), as well as acting as a deterrent to inflation. The most conspicuous indirect net benefit of small-scale animal agriculture is that small stock, rural poultry, and mini livestock, for example, rabbits, guinea pigs, and others that dominate backyard production systems, provide an important source of part-time job opportunities, particularly for landless women and children. In different agro-ecological regions, species of bovines, equines, camelids, and elephants are all used as sources of draught power for a variety of purposes in the smallholder farming sector, such as pulling agricultural implements, pumping irrigation water, and skidding in forests.

7. SCAA in integrated crop-livestock systems for food security

Mixed crop-livestock farming has gained widespread acceptance as an economically and environmentally sustainable farming system and bears a large portion of the weight of the world's food systems. A robust and widespread association between mixed-crop-livestock farming and sustainable agricultural methods was demonstrated by the International Center for Tropical Agriculture^[97]. The production of mixed crops and livestock is thought to benefit food security. In order to handle complicated issues with productivity in small-scale livestock smallholders' production systems, a proper framework for an integrated crop-livestock system is essential. Therefore, it is important to prioritize agricultural programs that favor mixed-crop livestock farming.

The interconnectedness of crop and livestock components in the smallholder farming sector, which were previously thought of as separate components and processes in African agriculture systems, has been better understood as a result of extensive agricultural systems research. Crops and livestock are no longer sufficient to make inferences about the whole system since interactions across agricultural system components can significantly affect system responses when given the right conditions^[98]. **Figure 1** shows a simplified mixed crop-livestock model in rural areas of Africa.

There are numerous advantages to crop-livestock integration in small-scale agriculture farming in Africa, but these are dependent on the farmers' sociocultural preferences as well as the biophysical conditions as determined by rainfall, radiation, soil type, and disease pressure^[99]. Mixed crop and livestock farming has shown some success by focusing on the use of integrative and holistic mechanisms and rationally building on and using the natural and local resource base without exhausting it, while enhancing biodiversity, optimizing complementarities between crop and animal systems, and finally increasing opportunities in rural livelihoods^[100]. Even in integrated systems, the exchange of resources such as dung, draught, and crop residues takes place to varying degrees depending on the availability of land, labor, and capital^[101].

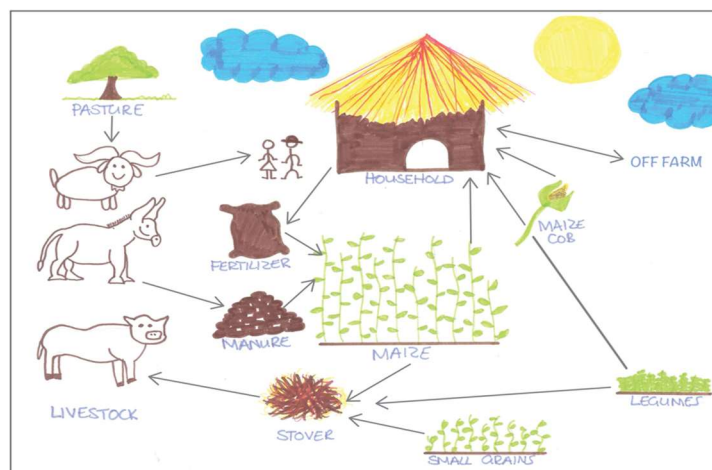


Figure 1. A simplified mixed crop-livestock model in rural areas in Africa.

Mixed-crop-livestock systems are probably the most well-known type of integrated mixed farming. Mixed crop-livestock systems provide numerous options for adapting to climate change and reducing crop and livestock production's contribution to GHG emissions. In the face of climate change, a mixed crop-livestock system is an example of a climate-smart agriculture technology that is strategically designed to achieve long-term development and food security. However, much is known about the effects of climate change on crop enterprises in mixed systems, as well as some, albeit less so, on livestock enterprises^[96]. This is a significant gap, as these interactions may provide some buffering capacity to aid smallholders in climate change adaptation.

Crop and livestock integration is becoming more appropriate as a result of the fact that small-scale farm size in Africa is gradually declining due to population pressure, and this trend is inversely proportional to rural population density. Given the continent's limited static supply of cultivable small-scale farmland, the pure dynamics of cultivated rural population concentration point to a reduction in average farm size^[102]. As a result, the pressure on decreasing available grazing land due to increased population density in rural areas will continue to increase, as will the pressure to produce more quantity, variety, and quality of animal product-related food, potentially having a negative impact on food security.

A positive relationship between livestock and cropping systems could be restored throughout much of Africa if they were occasionally better integrated. Improved information access and cultural acceptability can boost the adoption of climate-smart options in mixed livestock-crop systems through research and extension. Africa's efforts have been significantly hampered by the absence of a comprehensive agro-ecosystem strategy, which limits the benefits of mixed crop-livestock farming. Many countries in sub-Saharan Africa have not fully embraced the holistic (crop-livestock integration) food system approach to solving food poverty, particularly in small-scale farming systems, despite the continent still having low food productivity and resource efficiency.

8. SCAA in agroforestry (agro-silvopasture systems) for food security

Agroforestry (AF) is defined as "a land use that involves deliberate retention, introduction, or mixture of trees or other woody perennials in crop or animal production fields to benefit from the resultant ecological and economic interactions^[103]." Agro-silvopasture is one of the agroforestry for livestock technologies; it is a very diverse system of land use that combines animals, trees, and agricultural crops^[104]. Pell^[105] and Borad on Science and Technology for International Development^[106] both provide examples of animals in agroforestry systems, including: (i) chickens in garden systems, orchards, and forests; (ii) ducks in aquatic environments,

such as rice paddies; (iii) geese to control grasses in orchards; and (iv) livestock in forest plantations (agro-silvopasture systems).

Agro-silvopasture systems are increasingly being shown to be a viable alternative to resource-constrained agricultural systems that may be highly dependent on external inputs, a good example being small-scale animal agriculture. Small-scale animal husbandry uses agro-silvopasture systems, which have significant socioeconomic advantages with equivalent production conflicts. The conflict from agroforestry systems in small-scale animal agriculture may arise from crop damage by animals, which is more likely when livestock and crops are integrated. After harvest, allowing livestock to graze on fields could compact the soil^[107]. Small-scale agriculture can maximize production, which will increase livestock production and advance food security if animals are raised as part of agroforestry systems. The majority of Africa's population depends on its immediate ecosystems for survival, and the continent continues to struggle with the effects of climate variability and change in Africa, the use of fodder agroforestry technologies has benefited smallholder animal farming. When there are extreme climatic conditions, like droughts, fodder agroforestry technology has been able to provide the resources needed for animal feed. Muthee et al.^[108] discovered that by incorporating trees into their farms, farmers gain a variety of livelihood and environmental benefits, improving food security, income, farm productivity, and environmental sustainability. The majority of these have been tested and found to be effective in specific agro-ecological regions of the continent. Agroforestry systems that incorporate animals with tree crops can improve important natural cycles such as nutrient cycling, hence facilitating an ecological balance while using less energy. The key is to integrate animals' natural needs, behaviors, and products with the environment provided by the silvo-pasture agroforestry system in a way that maximizes the benefits to the animals and the farm system as a whole^[109].

The gender and generational division of labor in activities related to agriculture, such as agroforestry, has been noted to be complicated^[110]. Although there are differences between farms and men and women have extensive knowledge and skills, some gender-related patterns in agroforestry have been observed. Men are more likely to be commercially interested in agroforestry^[111], whereas women prioritize family needs by investing more in health, sanitation, and education^[44].

Agro-silvopasture systems have been shown to be an essential component of climate change adaptation and mitigation^[112] in small-scale animal husbandry, and this can greatly increase animal output and, consequently, food security. By regulating microclimate, preserving long-term soil health, reducing the prevalence of insects and pests, and balancing temperature^[113], agroforestry practices also aid in climate change adaptation. Previous research has shown evidence of the agroforestry systems' capacity to sequester carbon^[114–116]. One of the main components of several Sustainable Development Goals is the use of soils as carbon sinks, particularly Goal 15: “Protect, restore, and promote sustainable use of terrestrial ecosystems; sustainably manage forests; combat desertification; and halt and reverse land degradation and halt biodiversity loss.”

Understanding how agroforestry and livestock management might complement one another in small-scale animal agriculture is essential because both have the ability to increase anthropogenic climate change resilience. The majority of studies only quantify the amount of carbon stock in smallholder systems^[117] or the role of agroforestry in building resilience to climate-related hazards^[118]. Small-scale animal producers should consider silvo-pasture systems to be a type of agroforestry approach. Trees and shrubs have enormous potential to improve livestock management by providing diverse fodder, wind and heat protection, more resilient grazing land, and thus improved animal health^[119]. Agroforestry is frequently mentioned as a solution to the dual challenges of climate change and food security^[120]. Fodder agroforestry practices are applicable to smallholder livestock farmers who are highly exposed to climate change effects and variability.

9. Inter-relationship between SCAA, climate change and food security

Food security, agricultural and animal productivity, and both, are projected to face an increasing number of adaptation-related issues in the coming decades. Therefore, agriculture contributes to the fight against climate change. African agriculture already faces a difficult challenge in meeting the need for food from a growing population, and climate change will make things even more difficult. In order to establish strategies for greenhouse gas (GHG) emission reduction, African nations have long depended on the default emission factors provided by the UN Intergovernmental Panel on Climate Change (IPCC). This is due to the fact that measurements of GHG from agriculture and livestock systems are quite scarce in the majority of developing nations. Climate change is anticipated to negatively affect smallholder livestock production systems in sub-Saharan Africa, which are crucial to rural populations' livelihoods^[121]. Environmental disturbances brought on by climate change are already occurring and will continue to do so, making resource-constrained rural indigenous livestock and poultry-rearing systems in Sub-Saharan Africa more vulnerable. Risk aversion is crucial since more changes are expected to occur in the region's rural, resource-poor areas than anywhere else. Rural communities with limited resources and a reliance on agriculture face socioeconomic and environmental difficulties as a result of the dangers associated with climate change.

Due to its impacts on the quality of forage and feed crops, water availability, milk production, livestock diseases, animal reproduction, and biodiversity, climate change poses a threat to the production of livestock. The majority of animals that are susceptible to heat stress are those with strong reproductive capacities. The precise impact of climate change on future agricultural productivity is difficult to predict due to uncertainty in projections, but studies have consistently found that under the majority of scenarios, significant negative effects should be anticipated globally. Our capacity to adapt small-scale animal husbandry systems to climate change will determine food production and security in a scenario of climate change. For Africa, climate change is one of the factors that will negatively affect food production, hence food security^[122]. This is due to the fact that a larger portion of food production is heavily dependent on small-scale agriculture, which is strongly linked to the usage of natural resources, which are most susceptible to climate change. However, the impact on Africa may be especially severe due to the continent's low capacity for adaptation and heavy reliance on rangeland-based animal production systems. The security of food has to do with this.

Numerous projections of the effects of climate change on the African animal and agricultural sectors may be found in the literature. Additionally, CSA can aid in the development of adaptive capacity so that farmers, agricultural service providers, and important institutions are able to both successfully respond to longer-term climate change and manage the risks associated with it. The bulk of the world's unemployed work in smallholder animal agriculture, which also provides significant portions of the food in underdeveloped nations while being extremely vulnerable to environmental change. Because small-scale animal husbandry has always been a fragile industry and because climate change is making the issue worse, attention is being paid to viable solutions for climate change concerns in Africa's animal agriculture. While increasing the likelihood of substantial animal losses, it has the potential to reduce average animal output. **Figure 2** shows the inter-relationship between small scale animal agriculture, climate change, and food security.

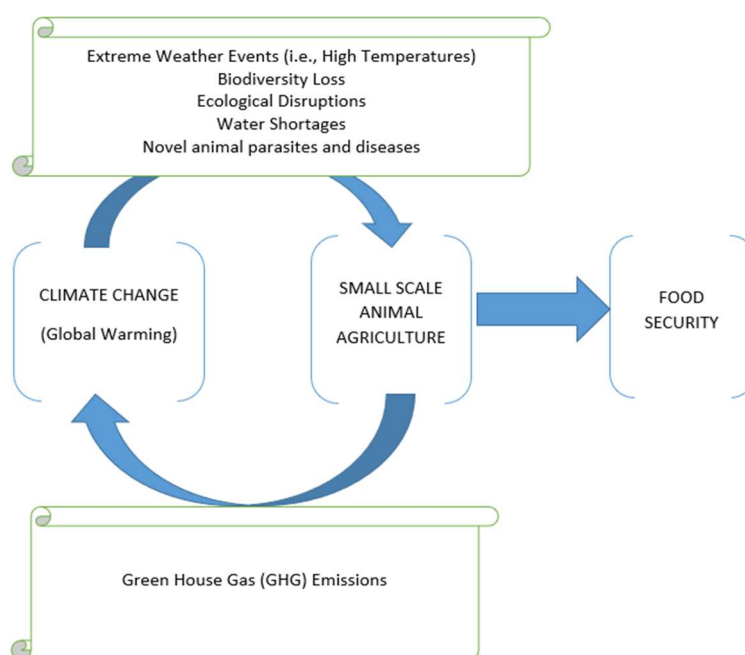


Figure 2. Inter-relationship between small scale animal agriculture, climate change and food security.

Sub-Saharan Africa is endowed with diverse and locally adapted native livestock and poultry breeds/varieties that have continued to sustain production in rural areas despite the harsh and extreme environment caused by climate change, including diseases and parasite infections, heat stress, and feed and water scarcity. Indigenous cattle and poultry genetic resources are crucial for the wellbeing and livelihoods of smallholder farmers who lack access to resources, as well as for food security, nutritional status, and other socioeconomic and environmental advantages. The genetic resources of local animals, such as grazing habits, tolerance to diseases, and heat resistance, are anticipated to play an increasingly significant role in the livestock and poultry systems of smallholders as the environment becomes more unpredictable due to climate change. A deeper comprehension of how social, economic, and environmental repercussions interact is required to address concerns related to climate change.

Goats and sheep in particular can be quite helpful in assisting rural communities to adapt to and lessen the consequences of climate change. It is predicated on the idea that selecting an animal species that has adapted to its environment will lessen adverse consequences of climate change. When it comes to the effects of climate change on small-scale animal farming operations or activities, men and women face specific gendered vulnerabilities. Determining the extent to which a lack of gender-sensitive planning has raised the risk to animal production and outlining possibly engendered strategies for interventions to lessen the effects of prospective setbacks in animal production are therefore crucial.

The potential of this agriculture subsector must, however, be fully realized in order to guarantee regional food and nutrition security as well as ongoing rural and economic development. In Africa, the majority of farm holdings are farms with less than two hectares. Researchers, development experts, and policymakers must comprehend the importance of small-scale animal agriculture farming to Africa's development agenda if this industry is to succeed. The body of knowledge on small-scale agriculture farming, the challenges and opportunities they encounter due to climate change, and their adoption of practices that, despite being underfunded in this field, embody the principles of ecological and climate-smart animal agriculture.

10. Gendered climate change risks and food security in SCAA

Recently, there has been a surge of interest in the gender and social inclusion agenda in relation to gender equality and empowerment in climate resilient agriculture^[123]. This implies that the gender approach has thus been to understand the gender gap in agriculture as a result of climate change while also researching climate-smart solutions to promote gender equality and women's empowerment. Understanding gender perspectives on small-scale animal agriculture and disease prevention.

Climate change has continued to impact small-scale animal agriculture and the general livelihood choices and food security status of women and men differently, determining their individual capacity to respond to a crisis such as food insecurity shaped by climate change itself and other socio-economic conditions. In this case, it seems women are more vulnerable to climate change, and women are typically portrayed as a homogenous group^[124]. This is given that the subject of gender merely serves to further complicate the already complex issues of susceptibility and adaptive ability. While everyone is affected by climate change, its effects vary disproportionately depending on different identity intersections.

In small-scale animal agriculture, gender identity has been identified as a key contributor to climate change susceptibility. In the smallholder agricultural sector, little research has been done on the dynamics and realities of gender-differentiated effects of climate variability on men and women engaged in small-scale animal husbandry based on their capacity for adaptation and coping. As major players in small-scale animal agriculture, women are crucial in addressing and leading initiatives to boost local rural economic growth through their role in animal farming and enhancing livestock health, consequently enhancing household food security. Hence, to adjust to climate stressors, policies addressing the contextual understanding of gender-variegated susceptibility in small-scale animal agriculture are required. Women continue to play a significant role in household livestock decision-making, including decisions about animal care, animal feeding and breeding, the use of livestock-farming byproducts, and animal-related aspects of food security, despite their vulnerability to stressors related to climate change.

Gendered solutions that support regional and local adaptation planning are essential, paying close attention to any sudden climatic shocks and changes in cattle production. The guiding concepts of climate-smart agriculture are founded on the need to: improve farmer productivity and, consequently, livelihoods; make farms more resilient to current and anticipated future climate impacts; and, where practical, reduce greenhouse gas emissions related to food production and security^[125]. As a result of climate change, climate-smart agriculture is a method for creating agricultural strategies to ensure sustainable food security. In general, the effects of climate change put rural population livelihoods and food security, which are usually already in peril due to socioeconomic and environmental issues, in an even precarious position. The expense of adaptation strategies, the existence of relevant institutions, access to technology, and biophysical limits like genetic variety for regional animal genetic resources all play a role in how small-scale animal agriculture in Africa adapts to climate change (e.g., the development of heat-tolerant animal breeds). Many of the negative effects on livestock and rural poultry productivity may be mitigated by adaptation methods created to foresee anticipated climate change effects on animal output.

11. Climate smart SCAA: An approach for sustainable food security

Africa can improve food security by giving climate-smart animal husbandry technologies top priority in small-scale animal agriculture. In order to increase small-scale animal productivity, enhance food security, build resilience to climate change, and mitigate climate change, it is urgent to develop and implement "climate-smart" animal husbandry management options^[126,127]. For the purpose of promoting food security, it is

necessary to test different adaptation strategies utilizing on-farm research to see how any suggested climate-smart animal agricultural technologies will enhance animal agriculture-related components of food security. In light of population growth, changing dietary preferences, and climate change, agricultural diversification has been identified as a critical strategy for promoting food production and improving food security^[128,129].

Crop-livestock integration has proven to be one of the broader “solution areas” for climate change mitigation trade-offs in small-scale animal agriculture in this context. It should be noted that there is no one-size-fits-all approach, and each farming system will experience the effects of crop-livestock integration methods in a different way and to a different extent^[130]. The intricate relationships between the many parts of crop-livestock production systems must be taken into account in order to maximize the effectiveness of mitigation techniques and prevent environmental trade-offs. Breeding strategies and the use of adapted local animal feed resources can be effective mitigation measures. The debate asks for a paradigm shift in rural development and food security policies, preferring indigenous animal genetic resources and capacities over imported genetic resources that are inflexible.

A long-term strategy for Africa’s small-scale farming sector to address the food crisis made worse by global warming should include supporting and developing native animal genetic resources, even though putting into practice climate-smart animal husbandry practices in the short term is important. On-farm and off-farm actions, as well as technologies, policy, institutions, and investment, are all part of CSA. It is a method for developing agricultural strategies to ensure long-term food security in the face of climate change. Small-scale livestock productivity is quickly increased by interventions that emphasize the promotion of suitable feed resources. However, this is dependent on the size of the farm, and the age distribution and herd size are typically influenced by the socioeconomic environment.

By making breeding efforts to promote heat tolerance, productivity can be raised in non-grazing livestock systems. Livestock financial insurance as a mechanism to deal with environmental risks is not a practical option for small-scale animal husbandry because of a number of factors, including the fragile economies of the majority of African countries and the incapacity of livestock insurance instruments to handle climate-related risks associated with extreme events. This is most likely because climate science in relation to livestock production is still in its infancy in Africa; however, indigenous knowledge systems and climate science must be integrated for use in small-scale farming in the future.

Farmers are the main custodians of knowledge about their local agroecosystems, genetic resources for local crops and animals, and climatic trends. With the assistance of local organizations and programs, farmers can identify acceptable climate-smart options that are simple to adopt and implement. Without a doubt, small-scale animal agriculture is critical to ensuring food security; therefore, identifying adaptation and mitigation methods and practices for use throughout the entire livestock production and supply chain is critical to maintaining productivity and improving food security on the continent. On the other hand, small-scale animal agriculture management is a conduit that assists the global effort to reduce greenhouse gas emissions.

12. Conceptual framework for SCAA and food security

Small-scale farmers are essential to addressing the continent’s hunger issue. Small-scale animal farming should receive the attention it deserves to improve its capacity to meet food security needs. It has long been believed that small-scale animal agriculture could only be enhanced by reducing the incidence of a select few animal diseases and enhancing animal nutrition. The production support for small-scale animal agriculture is organized into a production line, a supply line, and one or more service lines. The biggest obstacle to SCAA is organizational, not technical. The majority of African nations have weak institutions, which hinders SCAAs’ access to markets and credit. These elements, including a lack of adequate infrastructure, have limited

smallholder farming's ability to increase productivity. Any plan to boost the productivity of small-scale animal agriculture should seek to address these factors holistically, as shown in **Figure 3**.

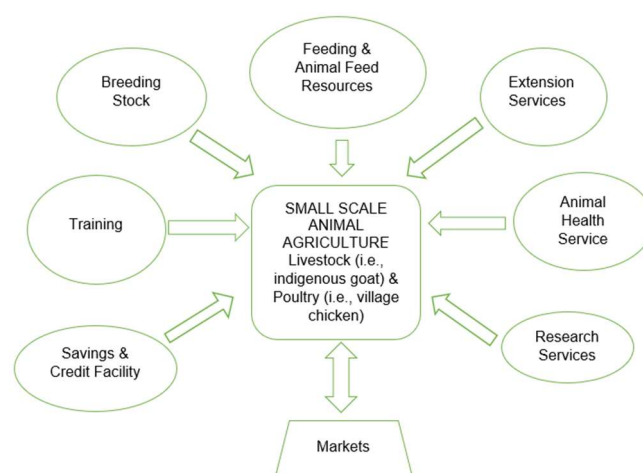


Figure 3. Determinants of small-scale animal agriculture productivity.

13. Future of SCAA research and development and food security

Traditionally, the goal of agricultural research and development (R&D) has been to find solutions to the problem of feeding the world's hungry people. What are the most crucial inquiries to make in this situation? The continent might be able to prevent the issue of food insecurity if these can be precisely identified and questions about them are properly investigated. In light of its effects on security and small-scale animal production, Africa needs to reevaluate its R&D strategy. African countries seem to underinvest in agricultural research and development and have limited human resource capacity. African agricultural research groups continue to struggle with poor administration and organization. Strategies are required for Africa to transform its small-scale animal agriculture. Rural livestock breeding and improvement strategies should be based in the community and tailored to the needs of smallholders.

14. Agricultural extension, education and training and food security

Agricultural extension, education, and training are essential for boosting SCAA animal production and food security. Agricultural extension is essential for boosting smallholder agricultural output, boosting food security, enhancing rural livelihoods, and promoting agriculture as a source of pro-poor economic growth. A Training Needs Assessment (TNA) is required to improve the efficacy of agricultural extension and education in smallholder livestock production. Extension programs are anticipated to contribute to boosting farm output and income, lowering poverty, and reducing food insecurity^[131].

Extension, according to Bonye et al.^[132], is the knowledge and resources needed to participate in commercialized agriculture are often lacking. There is a lack of technical know-how among local farmers regarding how to deftly combine modern technology with well-established and tried-and-true traditional farming methods. Anderson and Feder^[133] concur that agricultural extension services are essential for enhancing farmers' abilities to uphold sound agricultural practices, such as controlling livestock diseases and pests and providing farmers with access to inputs, services, and markets. Additionally, farmers require quick advisory services so that they can quickly modify their systems and procedures to deal with interruptions in the availability of inputs, labor, money, and markets. Programs to advance human capital in agriculture are still one way to improve farmers' familiarity with new technological developments^[134].

Extension programs are anticipated to contribute to boosting farm output and income, lowering poverty, and reducing food insecurity^[131]. Through a constant process of construction, it is becoming more and more important to have highly developed technical skills across a wide range of food and farming systems and highly developed socio-political perspectives on the role of farming in society. As a result, it's crucial to develop the skills of agricultural extension workers using current and appropriate techniques for rural development. The main barrier preventing women farmers from acquiring the fundamental knowledge they need to raise animals in order to increase output, efficiency, and income has been gender disparity in agricultural extension. This is despite the fact that women are actively engaged in and urgently need extension services to improve farming practices and the tasks they carry out for processing, storage, and marketing.

There is a significant gender gap and poor representation of women among extension advisors, which puts agricultural transformation and the sector's overall development at risk given that women make up about 43% of the agricultural labor force globally and in developing countries^[135]. Ragasa et al.^[136] noted that when providing extension services to the smallholder farming sector, it is becoming more and more important to consider gender because it enables the development of better strategies for encouraging both male and female farmers to adopt new technologies and farming practices in line with their roles, skills, and capacities, in this case in relation to animal production activities.

The UN's Food and Agriculture Organization^[137] claims that women have a significant impact on agriculture work because they make up 40% of the labor force, which is between 60 and 80% in both Asia and Africa. A new extension services framework is required in Africa in order to reform and revitalize extension services in the smallholder farming sector, where gender issues are adequately addressed. Experimental data suggest that information and communication technologies (ICTs) can be used to provide smallholder livestock farmers with agricultural advice or extension services^[138]. However, such a strategy is not always successful and has frequently proven difficult to implement on a large scale, especially in highly dispersed smallholder farming systems.

15. Animal health delivery systems in SCAA and food security

Dione et al.^[139] cited the following as some of the main constraints faced by animal health service providers: self-medication practiced by farmers, lack of knowledge of farmers on animals' management, poor drug handling and storage, lack of transportation means for health workers, and poor market harmonization. The assessment of the performance of the animal health delivery services targeting small-scale animal agriculture is essential in order to determine constraints and opportunities for intervention along the production value chain. Africa is lacking in smallholder animal delivery systems; a lack of appropriate service providers has been a major problem for smallholder farmers. Due to the lack of poorly organized systems, characterized by poor implementation of quality assurance of the products, this has impacted small-scale animal production.

The main constraints are related to a lack of professional animal health workers, poor drug handling and administration, high transaction costs of drugs and services, and poor transport means related to bad road status and the high cost of fuel. As a result of these, smallholder farmers face low productivity and high livestock and poultry mortality due to the low effectiveness of treatments coupled with weak biosecurity measures. There is a need to strengthen the health services delivery node and reinforce health delivery systems policies to support small-scale animal agriculture in Africa. Lack of close monitoring of service delivery and disease monitoring systems related to small-scale animal agriculture has hampered smallholder farmers have access to high-quality animal health products and services, impacting the whole issue of animal productivity. Lack of drug control could result in an increase in pathogen resistance to specific drugs, mainly antibiotics and acaricides, compromising livestock production.

16. Farmers access to inputs, credits and markets and food security

Most developing countries encounter institutional and technical barriers that may prevent the small-scale farming sector from taking part in new food security initiatives meant to improve rural livelihoods. Small-scale farming has a significant market opportunity due to the growing significance of rural-urban linkages, structural change in many middle-income countries, and generally rising global demand for food and fodder^[140]. According to reports, 2/3 of the 3 billion rural people living in developing countries work on land plots smaller than two hectares and are housed in about 475 million small farm households^[141]. The majority of these farmers lack access to markets and services, are undernourished, and live in poverty. Over time, it has been suggested that achieving proper integration of smallholder agricultural households into the local, national, and international agricultural markets is a viable approach to achieving the sustainable development goal^[142]. Attempts to build market connections for smallholder agricultural production have encountered a number of constraints. Smallholder farmers frequently practice low input agriculture because of their poverty rather than out of choice. Smallholders' participation in the market is thought to contribute to agricultural development and growth, resulting in the much-anticipated structural transformation of the agricultural industry and a shift toward the reduction of extreme poverty and food insecurity among agricultural households in Sub-Saharan Africa (SSA).

Reorienting policy is necessary to realize this potential, particularly to improve market and credit access, technology adoption, and animal husbandry management practices. Improved access to animal production inputs (e.g., feed, vet medicines, etc.) is also necessary for increasing animal productivity, which is increasing the consistently low animal performance. Lately, microfinance institutions have increased financial services to millions of customers who were previously unbankable. However, they have so far largely failed to reach poorer rural areas and/or small-scale animal farmers whose livelihoods are characterized by highly seasonal investments, risks, and returns^[143]. Therefore, policies that improve access to the markets for inputs and outputs are still crucial to enhancing animal production in the smallholder farming sector. Improved small-scale animal farmers' access to established and developing markets calls for special consideration.

Small-scale livestock producers in rural areas make up a significant portion of Africa's agricultural industry. These small farmers have great opportunities due to the increased demand for food and animal products across the continent, but they also face significant difficulties. It should not be overemphasized that the lack of organized markets is one of the main obstacles to small-scale animal agriculture. Various sources have acknowledged the need for an organized market to encourage farmers to produce beyond what is necessary for survival. Markets and improved market access are crucial for raising smallholder farmers' incomes in developing nations^[144]. Despite this, a number of obstacles prevent smallholder farmers from participating in markets in the majority of sub-Saharan African nations. Insufficient market access is one of these limitations^[145].

Farmers markets provide small and mid-sized farmers with a low-barrier entry point to establish a successful agriculture enterprise with a commercial orientation, which helps to promote the sustainability of small-scale animal agriculture^[146]. For farmers to be successful and productive, they must have easy access to profitable markets. All agriculture that has successfully transformed shows this. Small-scale farmers can be motivated to produce quality animal-related products if their access to markets is improved.

Ordinarily, smallholder farmers struggle to find suitable markets, resulting in a lot of productivity losses from any excess products. A major contributing factor to small-scale animal agriculture's low productivity is improper marketing. Farmers are unable to obtain a fair price for their goods and are forced to sell their produce at low prices to local money lenders due to inadequate transportation. Due to improper storage space or

facilities, farmers are unable to store their animal-related produce when prices are low because there aren't enough warehouses available. Therefore, these contribute significantly to agriculture's low animal productivity.

The two main approaches for connecting small-scale farmers to the market are improving access to credit facilities and strengthening ties between farmers and consumers. Small-scale livestock farmers in African nations encounter high storage costs, poor infrastructure, and high transportation costs. These farmers are unlikely to take the risk of producing an abundance of goods if they think their products will go to waste. Due to inadequate market knowledge, most farmers are unaware of potential markets because small-scale animal farmers are dispersed, poorly organized, and lack communication tools. Where extension workers are available, they rely on them; otherwise, they rely on word of mouth, where the information is frequently misrepresented or incorrect. Therefore, it is crucial to create a good information system for small-scale animal farmers so they can decide for themselves what is best for their community.

A lack of adequate or nonexistent transportation infrastructure makes marketing agricultural products unprofitable. The majority of productive areas are inaccessible and poorly connected to the major market centers. Due to the fact that transporters must account for wear and tear costs, transportation to and from these locations is very expensive. By improving feeder roads, governments can hasten the growth of smallholder commercial agriculture production. Marketing infrastructure needs to be strengthened and expanded in order to help smallholder farmers sell their animal products at fair prices. The markets' produce should be sold using appropriate marketing strategies. The implementation of a price support policy and the guarantee of minimum prices for the peasants are additional requirements.

If agriculture and food programs are inclusive, growth, poverty reduction, and addressing food insecurity in small-scale farming can be achieved. The idea behind using inclusiveness to advance smallholder welfare is that greater well-being can be attained through capacity building and economic stability, both of which can be produced by inclusive growth. According to Abiodun et al.^[147], the majority of agricultural program opportunities were not inclusive, with the exception of income growth and gender equity. Growth had a sizable impact on farmers' productivity. It was suggested that agricultural programs be carried out using a bottom-up approach and that smallholder farmers be encouraged to build their capacity. According to Etwire et al.^[148], smallholder farmers' level of inclusion in agricultural programs will increase if they have simple access to credit and markets. Smallholder farmers will have easier access to agricultural credit institutions if they are locally based in rural areas. To encourage smallholder farmers to obtain credit for business expansion, credit agencies and institutions should have flexible policies. Most developing countries encounter institutional and technical barriers that may prevent farmers from taking part in new food security initiatives meant to improve rural livelihoods.

Otekunrin et al.^[149] believe that for many African countries, the transformation of small-scale animal agriculture into a commercial orientation through the creation of organized markets is a necessary path to agricultural and economic growth and development. Small-scale animal farmers' market participation helps drive agricultural growth and development, resulting in the much-anticipated structural transformation of the agricultural industry and a shift toward reducing poverty and the alarming food insecurity of agricultural households in Sub-Saharan Africa. Therefore, it is crucial to support SCAA as farmers modernize their animal husbandry operations in order to develop successful animal production ventures that can bring in enough revenue to meet their households' needs and food security. In order to reduce poverty, SCAA programs should prioritize connecting farmers to the formal meat markets and other service providers.

17. Implications

Africa's SCAA and food security are at a crossroads; if decisions aren't made now to support small-scale animal agriculture, the continent will either continue to be hungry and a net importer of food or be vulnerable to failure from any wave of unpredictable change, including climate change. By 2050, as expected in SGDs, improving small-scale animal agriculture may trigger a rapid transformation in animal production and food security that brings prosperity, resilience, sustainability, and all other desired outcomes. SCAA is a crucial element of the continent's food security in Africa's rural communities with limited resources, and food insecurity is perpetual. The primary food producers in Africa are small-scale farmers who exhibit low agricultural output. The development of smallholder farmer production must be given top priority in the effort to increase productivity and improve food security. To change farming from a solitary, survivalist enterprise into sustainable livestock production family units, they need the assistance necessary.

Small livestock and poultry in rural areas contribute to all aspects of food security and empower women to reduce gender inequality. Additionally, compared to large ruminants, they have a lower environmental impact because of their smaller bodies and can efficiently contribute to the cycling of nutrients in the ecosystem. Local animal genetic diversity is greatly influenced by small-scale animal agriculture, which also helps to preserve native breeds and chicken ecotypes or variants. SCAA has the potential, if correctly utilized, to help accomplish the Sustainable Development Goals.

A transdisciplinary science approach is required to adapt to the increasing food demand brought on by population pressure while addressing gender inequality and mitigating the effects of climate change to enhance food security in SCAA in Africa. Cross-cutting and multidisciplinary science solutions are now required to boost SCAA due to the numerous socio-economic, ecosystems' services, and livelihood endeavors development challenges that Africa's rural population is facing, including climate change, gender inequality, high levels of poverty, and food insecurity. Agroforestry (the integration of crop and pasture lands) and mixed crop and livestock farming will both produce multiple ecosystem goods and services and more likely improve food security.

Africa's population is expected to quadruple by 2050, yet current trends in food production imply a decline rather than an increase. Most of the poorest in Africa live in rural areas, where agriculture is their main source of food and income. To accomplish the SDGs, major support is required to reform smallholder farming sector.

For rural communities that rely on non-grain dietary sources (such as pastoral societies), the commonly discussed version of food security has been misleading. Any SCAA development strategy must contextualize livestock and rural poultry development programs from the perspective of local farmer preferences and practices.

In Africa's resource-strapped rural areas, climate-smart SCAA will safeguard better livelihoods and strengthen food security. Food insecurity has become a critical concern as target populations are among the most susceptible to and affected by climate change. It is necessary to investigate the factors that contribute to climate change vulnerability and adaptation options for livestock farming in various agroecological zones.

Despite all the challenges associated with climate change, the SCAA seems to persevere and be determined to still produce animal-related foods and improve their livelihoods. Small-scale animal agriculture should be transformed in terms of production practices and breeding to meet food security demands. Climate-smart approaches in response to current and future social, economic, or competitive forces must be adopted.

Adaptation measures designed to anticipate the potential effects of climate change on animal production could help to offset many of the negative effects on SCAA productivity and sustain food security. Admissible funding and localized climate change adaptation information are advised. The production difficulties in SCAA are made worse by the limitations brought on by climate change and the resulting environmental degradation. The potential of this agriculture subsector must, however, be fully realized in order to guarantee regional food and nutrition security as well as ongoing rural and economic development. Although there haven't been many in-depth investigations of the dynamics and realities of gender-differentiated effects on men and women in small-scale animal agriculture based on their capability to adapt and cope.

Africa has been led astray by some quarters into believing that it is misguided to focus on small-scale agriculture. Smallholder agriculture has received inadequate funding, and research and extension priorities have been shifted elsewhere. Africa has relied on prescribed research themes that do not align with the goals of small-scale farming.

Africa needs to go back to basics by refocusing its investments, research, and development on SCAA. Adoption of breakthroughs in animal genomics and information technology has the potential to improve output, but implementation requires access to technical and financial resources. Improved infrastructure, services, animal health care, marketing exploits, and other mediations would spruce up the long-term utilization of local animal genetic resources for food security. In the quest to address food security concerns, priority should be given to small-holder animal agriculture in order to promote structural change away from subsistence and toward commercial animal farming. Future priorities for improved SCAA should be based on the assumption that small-scale livestock farmers make rational and effective use of resources.

Conflict of interest

The author declares no conflict of interest.

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